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# Didactic Transposition Analysis on Line and Angle Concepts

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**ABSTRACT**

Mathematics knowledge in schools should be sourced from scholarly knowledge. Education not sourced from scholarly knowledge will risk errors in concepts, such as invalidly taught material, that can lead to misconceptions. This study aims to analyze the transposition of knowledge on the concept of lines and angles from scholarly knowledge to knowledge to be taught. This study uses a qualitative descriptive approach. The data source in this study, namely scholarly knowledge, was obtained by analyzing books in universities, while knowledge to be taught was obtained by analyzing mathematics textbooks used in schools. This study's results show a transposition process in the concept of lines and angles, namely in the definition of lines, the types of lines, the position of two lines, and the relationship of angles in two parallel lines. This research can later be the basis for improving mathematical knowledge so that student's understanding of the concept of lines and angles is expected to be more complete based on scholarly knowledge.



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## 1. INTRODUCTION

Mathematics knowledge in schools should be sourced from scholarly knowledge. Scholarly knowledge is developed through a research process that is tested by the scientific community [1]. Without a scientific basis, the material taught can contain conceptual errors that have the potential to confuse students. With a scientific basis, students gain a correct and comprehensive understanding of mathematical concepts [2], [3]. Scholarly knowledge allows the mathematics curriculum to remain relevant to the needs of society [4].

Education not sourced from scholarly knowledge will risk errors in concepts, such as invalidly taught material that can lead to misconceptions [5]. Learning comprises teachers, students, and materials [6]. Without the correct understanding, students cannot use mathematics for innovation. Scholarly knowledge provides a logical and systematic basis for mathematics education [7]. If school knowledge is not sourced from scholarly knowledge, the material taught can be wrong or irrelevant, and students do not understand

mathematics thoroughly as a structured science [8]. Materials that do not follow scholarly knowledge will be outdated and irrelevant to the future needs of students [9]. Students can lose interest in mathematics if the material is illogical or does not correspond to reality [10]. Mathematics education based on scholarly knowledge is not only an option but an absolute necessity to create quality and relevant education [11].

In mathematics learning, scholarly knowledge may be adapted so that students in school can learn it. The process is related to didactic transposition. The concept of didactic transposition was first introduced by Yves Chevallard, who explained that there are changes, simplifications, and meanings of teaching materials as scholarly knowledge is transformed into teachable knowledge in schools. This process can lead to a shift in meaning or even a distortion in understanding mathematical concepts. Therefore, it is necessary to redesign this knowledge to become meaningful and can be taught in schools [12]. Transferring from knowledge created and applied to knowledge taught is known as didactic transposition [13].

The didactic transposition process consists of two stages: external and internal didactic transposition [13]. In external didactic transposition, the scholarly knowledge produced by mathematicians is transferred to knowledge to be taught [14]. Meanwhile, internal didactic transposition is the transformation of knowledge to be taught into knowledge taught in the teaching and learning process by teachers in the classroom [15]. In this article, the transposition process discussed is limited to external didactic transposition.

Scholarly knowledge is developed through research and academic studies based on systematic scientific methods [16], [17]. This scholarly knowledge includes theories, scientific methods, and objectivity, and this knowledge is widely applicable and recognized by the scientific community [18]. Meanwhile, knowledge to be taught results from adapting scholarly knowledge to learn in the classroom. The characteristics of knowledge to be taught are simple and structured; that is, the meaning is adjusted so that students can understand it according to their level of education [19]. The following characteristic is contextual, which is associated with the situation or needs of students to increase relevance and relatedness.

Several studies have examined didactic transposition. Research that examines the concept of derivatives was obtained, and the results of the review in the context of knowledge to be taught revealed inaccuracies in the presentation of ideas, especially the definition of concepts of derivatives. The mismatch between formal definitions and learners' understanding in mainstream textbook-based learning leads to epistemological, ontogenic, and didactic barriers [15]. Research examining the concept of sets showed that the results of transposing the concept of sets from scientific mathematics to schools change the structure, form, and context. Scientific mathematics uses abstract formulas, while schools start from concrete to abstract [20]. Research that examines didactic transposition and learning trajectories shows a shift in concepts. The presentation of materials and learning trajectories in textbooks and learning has weaknesses, causing difficulties for students to understand the concept of sets [21].

These previous studies describe the materials that previous researchers have carried out. However, based on reference searches, no didactic transposition analysis research has

discussed line and angle materials. This study analyzes the didactic transposition process on line and angle materials. In particular, this study examines the compatibility between scholarly knowledge and knowledge to be taught in school mathematics textbooks. The research analyses how scholarly knowledge is transformed into material taught in schools through textbooks.

## 2. METHOD

This study uses a qualitative descriptive approach. This type of research is descriptive analysis. Descriptive research aims to describe the process of didactic transposition on line and angle materials. Analysis is a qualitative data collection technique that involves the collection and analysis of documents related to the subject of research [22]. This analysis was carried out on the first two units of didactic transposition: scholarly knowledge and knowledge to be taught. This study analyzes two data sources, namely university textbooks and school textbooks. The university textbook is taken from geometry material used in the Mathematics Education Study Program of the Muhammadiyah University of Bengkulu to study the concept of lines and angles in a scientific context.

Meanwhile, school textbooks include mathematics books at the junior high school level, grade VII, published by the Ministry of Education and Culture, especially in the section that discusses line and angle material. In qualitative research, the validity technique of the data carried out is validity. Qualitative validity is an effort to check the accuracy of research results by applying certain procedures, of which there are eight qualitative research validity strategies [23]. Of the eight strategies, the validation strategies used in the study include triangulation and external auditors. One strategy to get validation is with an external auditor. Another validation technique carried out by the researcher is to invite an auditor (external auditor) to review the entire research. In this study, we invited lecturers in the geometry course at one of the universities to assess this research. Data on scholarly knowledge is obtained by analyzing university books [15]. Analyzing school mathematics textbooks obtained data on the knowledge taught [15]. The analysis focuses on the compatibility between scholarly knowledge and knowledge to be taught in schools.

## 3. RESULTS AND DISCUSSION

Didactic transposition knowledge of lines and angles is obtained by analyzing the knowledge of lines and angles in each transposition unit, namely scholarly knowledge, line and angle knowledge in school mathematics textbooks, and knowledge to be taught. Furthermore, an analysis of the differences between knowledge in each transposition unit was carried out. The following are the findings about the line and angle knowledge obtained by the researcher in each unit.

### 3.1. Scholarly Knowledge of Lines and Angles

Scholarly knowledge about lines and angles is obtained from analyzing line and angle knowledge in textbooks or journal articles of research results. This follows the statement [24], which states that what is described in textbooks or journal articles as

research results is a priori or scholarly knowledge. The following results were obtained using the geometry book [25], [26].

Table 1. Summary of Line and Angle Textbook Analysis

| | ***Scholarly Knowledge*** |
|---|---|
| Line definition | A line is defined as a collection of points of infinite number, and a line has a length but no width or thickness [24]. In other words, we can connect at least two points to form a line. |
| Types of lines | A line can be straight, curved, or a combination of both. A straight line is formed by points always moving in the same direction. A straight line can extend in any direction indefinitely. A curved line is formed by a point that moves in an ever-changing direction. A line is named with a lowercase letter. |
| Two-line positioning | In the textbook, the position of the two lines is divided into 4, namely parallel, intersecting, intersecting, and perpendicular.<br>1. Parallel lines<br>Two lines are said to be parallel if they are located on a single flat plane, and if extended, they will not intersect (have no intersection points). The // symbol is used to indicate parallel lines.<br>2. Intersecting lines<br>Two lines are said to intersect if they lie on a flat plane and if they have an intersection point (Federation point).<br>3. Interlocking lines<br>Two lines are intersected if the two lines are located on one plane and intersect at all points.<br>4. Perpendicular lines<br>The lines meet each other and form a right angle. The symbol for perpendicularity is ⊥. |
| Definition of Angle | An angle is defined as two rays with the same endpoint that will form an endpoint called the angle point, and the line ray is called the angular side. Angles are measured in degrees from 0° to 360°, symbolized by ∠. Meanwhile, to show the size or magnitude of an angle is symbolized by $m\angle$. |
| Types of angles | Angles are divided into several types, namely:<br>1. Taper angle<br>A taper angle is an angle that is less than 90° in magnitude.<br>2. Right angle<br>A right angle is an angle that is 90° in magnitude.<br>3. Blunt angle<br>A blunt angle is an angle that is greater than 90° and less than 180°.<br>4. Straight angle<br>A straight angle is an angle that is 180° in magnitude.<br>5. Reflex angle<br>A reflex angle is an angle that is greater than 180° and less than 360°. |
| Angular-angular relationship on two parallel lines | A picture of a transverse line that cuts two parallel lines was given. From the figure, the angular relationship in two parallel lines is divided into several types, namely:<br>1. The opposite inner corners, the corners in the intersected lines, are on the opposite side of the transverse line, not side by side. |

| | ***Scholarly Knowledge*** |
|---|---|
| | 2. The opposite outer corners, i.e., the truncated outer corners, are on the opposite side of the transverse line, not side by side.<br>3. One-sided inner angles (inner corners are on the same side), i.e., inner corners on the same side of the transverse line.<br>4. Unilateral outer angles (the outer corners are on the same side), i.e., the outer corners on the same side of the transverse line.<br>5. Facing angles are angles that are faced in relatively the same direction. |

## 3.2. Knowledge of Lines and Angles in School Mathematics Textbooks (Knowledge to be taught)

The line and substitute material in the textbook [25] is presented in the line and angle chapter, especially in activity 7. The following describes the line and angle material contained in the textbook.

Table 2. Summary of Lines and Angles School Textbook Analysis

| | ***Knowledge to be taught*** |
|---|---|
| Line definition | In school textbooks, pictures of contextual examples in daily life are given that can define lines, such as bridges, railroads, boxes, flashlights, and backstaff. Then, the relationship between points, lines, and planes is given. So, a line can be defined as a straight line with two arrows at each end, indicating that the line is infinitely long. A line can be notated with lowercase letters, e.g., k, l, m, n, etc. |
| Types of lines | School textbooks have no information about the types of lines given or explained. In textbooks, everything explained is only about straight lines and no curved lines. |
| Two-line positioning | Given a two-line position table. In the first column, two lines are presented in the α plane. In the second column, two lines in the α in the third column describe the position of the two lines depicted in the previous two columns. Based on the table, some of the positions of the two lines are parallel, non-aligned, intersecting, squeezing, and perpendicular. Furthermore, below the table is described that the notation of the two intersecting lines is ×. The notation of two parallel lines is //. The notation of two lines intersecting perpendicularly is ⊥. |
| Definition of Angle | In school textbooks, illustrations of several activities or objects that form an angle are given, for example, an open laptop, a chair, the angle between the arms and body of a person who is archery, two sticks, and billiard balls, and the arms and body of a person who is pushing up. Then, illustrations of line rays and corner points are given. So, from the illustration given earlier, the definition of an angle is obtained, which is an angle formed from the intersection of two-line rays that intersect precisely at one point, so the intersection point is called an angle point. |
| Types of angles | The types of corners are also introduced in school textbooks, as follows.<br>1. Right Angle<br>The angle size is 90°.<br>2. Pointed Corners<br>The angle size is between 0° and 90°.<br>3. Blunt Angle<br>The angle size is between 90° and 180°. |

| | ***Knowledge to be taught*** |
|---|---|
| | 4. Straight Angle<br>The angle size is 180°.<br>5. Reflex Angle<br>The angle size is between 180° and 360°.<br><br>Any explanation of these angles is also given, as well as a picture or illustration for each angle except the reflex angle. |
| Angular-angular relationship on two parallel lines | The school textbook gives tables and pictures about the relationship of angles with two parallel lines. The relationship between angles and two parallel lines is given several names: outer angles, inner angles, opposite inner corners, opposite outer angles, unilateral inner angles, and opposite angles. |

Based on Tables 1 and 2 above, the definition of the line is simplified in the knowledge to be taught. In scholarly knowledge, a line is defined as an infinite set of points whose distance between points is very close, and the line has a length but no width or thickness. Meanwhile, in knowledge to be taught, a line is defined as a straight line with two arrows at each end and an infinite length. Thus, in the knowledge to be taught, the element of line formation is not explained.

Based on Tables 1 and 2 above, there is a discrepancy between knowledge to be taught and scholarly knowledge in the section of line types. In scholarly knowledge, it is explained that there are two lines: straight lines, curved lines, or a combination of straight lines and curved lines. Meanwhile, in the knowledge to be taught, the types of lines are not explained, and lines are only defined as straight lines. So, this can lead to a misperception of the line.

Based on Tables 1 and 2 above, in the position of the two lines, there is a correspondence between knowledge to be taught and scholarly knowledge. However, in knowledge to be taught, a term is added about the position of two lines, namely terms that are not aligned. In scholarly knowledge, the position of two lines is divided into several types, namely parallel, intersecting, pinching, and perpendicular lines. Meanwhile, the position of two lines in knowledge to be taught, namely parallel, non-aligned, intersecting, squeezing, and perpendicular. Thus, terms are added about the position of two lines on knowledge to be taught.

Based on Tables 1 and 2 above, in the corner definition section, there is already a correspondence between knowledge to be taught and scholarly knowledge. In Scholarly Knowledge, an angle is defined as two line rays with the same endpoint that form the endpoint, called angle points, and line rays are called angular sides. This aligns with the knowledge to be taught: an angle is defined by the intersection of two lines that intersect precisely at one point, where the intersection point is the angle point. Thus, the definition of the material from this angle does not change from scholarly knowledge to knowledge to be taught.

Based on Tables 1 and 2 above, there is a correspondence between knowledge to be taught and scholarly knowledge in the corner types. In scholarly knowledge, angles are divided into several types: pointed, right-angled, blunt, straight, and reflex. In the knowledge to be taught, the angles are pointed, right, blunt, straight, and reflex. This is in

line with research [26], [27] that there are five angles: pointed angles, right angles, blunt angles, and reflex angles. Thus, the material on the types of angles does not change from scholarly knowledge to knowledge to be taught.

Based on Tables 1 and 2 above, some conformities exist between the knowledge to be taught and scholarly knowledge in the angular relationship on two parallel lines. However, in knowledge to be taught, there is material that is not learned, namely one-sided external angles. This means that the one-sided outer angle is not explained in the knowledge to be taught, even though the relationship between the corners on two parallel lines has a one-sided outer angle.

Based on these findings, there is a change and simplification of the concept of lines and angles in the process of external didactic transposition, especially in defining lines and angular relationships in two parallel lines. Meanwhile, the term misalignment is added regarding the position of two lines. This can lead to the understanding that misalignment and intersection are different. If the discussion of lines is limited to only one plane, then two lines that are not aligned must intersect.

This difference in concepts can have a significant impact on students' understanding. For example, students may think of the term "misaligned" as something separate from the concept of "intersecting," resulting in difficulties in understanding the interconnectedness between line concepts. Simplification and addition of terms without sufficient explanation can lead to misconceptions, especially in understanding the position of lines in a flat plane and the relationship between parallel, non-parallel, and intersecting lines. These findings align with previous research that shows that changing terms or simplifying without a clear explanation can trigger student misconceptions and the importance of maintaining conceptual consistency between subject matter and scholarly knowledge to avoid misconceptions [28]. These findings follow the opinion [13], which states that all mathematical knowledge has a didactic transposition process. This has the potential to cause learning barriers in students [12].

## 4. CONCLUSION

Based on the results and discussion above, this study concludes that there are several adaptations in scholarly knowledge to knowledge to be taught online and angle material. The adaptation relates to the definition of lines, the types of lines, the relationship between two lines, and the position of the corners on two parallel lines.

These findings can be a reference for future research, and several areas can be explored further. One of them is to conduct an in-depth study of internal didactic transposition, namely how the material in the textbook is applied in the learning process in the classroom. In addition, further research can be focused on exploring didactic transposition in other mathematical topics, such as spatial geometry, to understand the patterns of adaptation of scientific knowledge in various mathematical concepts.

The results of this research are expected to make a real contribution to improving the quality of textbooks and the mathematics learning process in schools. Thus, students are expected to be able to understand the material taught better and more in-depth. These findings can also be helpful for the world of education, especially in increasing the

effectiveness of mathematics learning. This research can be used as a reference to improve the presentation of line and corner material in textbooks and teaching practices in schools.

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